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Charles A. Acosta



COVER: Harvest of queen conch (*Strombus gigas*) is prohibited in the Florida Keys.

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The move to electronic open access journals at AFS will increase our information transfer and address critical time-to-publication needs in the field of fisheries science and management without any nuance of grey.

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ESSAY: FISH CULTURE

Toward Sustainable Open Ocean Aquaculture in the United States

Robert R. Stickney
Barry Costa-Pierce
Donald M. Baltz
Mark Drawbridge
Churchill Grimes
Stephen Phillips
D. LaDon Swann

ABSTRACT: In response to a request by American Fisheries Society President Christopher Kohler, we examined the current status of open ocean aquaculture in the Exclusive Economic Zone (EEZ) of the United States, interest in open ocean aquaculture activities, the regulatory environment, and the potential for sustainable development. There is currently little interest in establishing facilities within the EEZ by the commercial sector, largely because of the lack of a formal regulatory structure, though that may be changing as Congress develops legislation on aquaculture in the EEZ. Current U.S. open ocean research and commercial activities are in state or territorial waters. The National Oceanic and Atmospheric Administration is poised to take the primary regulatory lead in the EEZ, with other federal agencies, such as the Minerals Management Service, Army Corps of Engineers, and Environmental Protection Agency participating. Under proposed legislation, coastal states would have the opportunity to comment on facilities in the EEZ adjacent to their jurisdictions. A variety of concerns pertaining to open ocean aquaculture development have been put forward that relate to environmental sustainability. We conclude that in the absence of large-scale facilities in the EEZ and associated research in conjunction with such facilities, the potential risks of open ocean aquaculture cannot be adequately evaluated. Data obtained from open ocean sites in other countries may or may not be applicable in this country's EEZ, but international cooperation in sharing environmental information from open ocean aquaculture operations can help researchers and regulators develop environmental safeguards and have them in place, if and when open ocean aquaculture becomes a commercial reality in the United States.

BACKGROUND

Late in 2005, American Fisheries Society President Christopher Kohler formed an ad hoc Open Ocean Aquaculture Committee to look at development of aquaculture in the U.S. Exclusive Economic Zone (EEZ), develop a summary of the existing situation, and begin to understand where this nation may be going in the future. The committee, chaired by R.R. Stickney, first met by conference call in November 2005. While the group recognized that there is a potential for employing open ocean aquaculture to produce fishes for purposes of stock enhancement, the decision was made to focus this report on aquaculture development in the U.S. EEZ for commercial foodfish production.

Some early publications on permitting in the EEZ, such as Stickney (1997) remain relevant, but the committee also sought more recent information. One significant resource was the final report of the U.S. Commission on Ocean Policy (2004). Recommendations from Chapter 22 of that document include amending the National Aquaculture Act to designate the National Oceanic and Atmospheric Administration (NOAA) as the lead federal agency for marine aquaculture and to create an Office of Sustainable Marine Aquaculture within NOAA; charging the Office of Sustainable Marine Aquaculture with developing a comprehensive permitting, leasing, and regulatory program; and expanding research, outreach, and technology transfer funding.

Stickney is director of the Texas Sea Grant College Program based at Texas A&M University, College Station. He can be contacted at Stickney@tamu.edu. Costa-Pierce is the Rhode Island Sea Grant director at the University of Rhode Island Narragansett Campus. Baltz is with the Coastal Fisheries Institute at Louisiana State University in Baton Rouge. Drawbridge is a senior research biologist at the Hubbs-Sea World Research Institute in San Diego, California. Grimes is director of the Southwest Fisheries Science Center, Fisheries Ecology Division in Santa Cruz, California. Phillips is program manager with the Pacific States Marine Fisheries Commission in Portland, Oregon. Swann is director for the Mississippi-Alabama Sea Grant Consortium based in Ocean Springs, Mississippi.

The National Aquaculture Act of 2005, which was reintroduced in 2006 (hearings were held but the bill has not been voted on at the time of this writing), calls for coordination by NOAA with other agencies, the fishery management councils, and the coastal states.

The Congressional Research Service updated a 2004 report on open ocean aquaculture (Borgatti and Buck 2006) that discussed the existing regulatory environment and mentioned NOAA's role as the lead agency in promoting development of the industry. Of interest is that currently a state with an approved Coastal Zone Management Plan (CZMP) can veto federal permits in the EEZ adjacent to their state if the permits are not consistent with the CZMP.

The most recent comprehensive look at permitting in the EEZ for open ocean aquaculture (Cicin-Sain et al. 2005) concluded that NOAA is the preferred lead agency to develop the regulatory scheme and suggested that NOAA create an Office of Offshore Aquaculture. As an agency within the Department of Commerce which has an interest in the

economic viability of such aquaculture activities, NOAA is well placed to be the lead agency. Thus, there appears to be broad consensus for NOAA being the lead agency with respect to aquaculture in the EEZ.

Cicin-Sain et al. (2005) made numerous recommendations with respect to collaboration among the various agencies that would be involved in the permitting process. In addition to NOAA, there would be involvement by the Minerals Management Service, NOAA Fisheries (which is a line office in NOAA), and the Environmental Protection Agency. (The Army Corps of Engineers should also be mentioned in this regard.) They suggested that four types of leases should be developed: research leases, short-term leases to enable firms time to further develop their business plans, long-term leases for those with fully developed open ocean aquaculture business plans, and emergency leases to allow rapid response for temporary relocation of a facility when circumstances warrant. Recommendations for environmental review and monitoring of open ocean aquaculture facilities were also developed to address carrying capacity, impacts from waste products on the water and sediments, potential genetic impacts, disease, and other issues.

We obtained additional information from Michael Rubino (michael.rubino@noaa.gov), who coordinates aquaculture activities for NOAA Fisheries. He provided information relating to the NOAA's role in open ocean aquaculture, the need for development of open ocean aquaculture in the U.S. EEZ, the legislation that has been introduced to Congress, and other documents. The Gulf of Mexico Fisheries Management Council has prepared a draft amendment on the regulation of open ocean aquaculture in Gulf waters and is presently finalizing that document prior to its adoption (Wayne Swingle, Gulf of Mexico Fisheries Management Council, pers. comm.).

In the past several years, numerous meetings in North America and Ireland focused on open ocean aquaculture have been held. Each led to publication of a symposium volume (Table 1). A book edited by Bridger (2004) chronicled research activity in the Gulf of Mexico in conjunction with development of open ocean aquaculture in that water body. The volume includes sections on constraints and sustainability.

Borgatti and Buck (2006) reported that open ocean aquaculture facilities (including those dedicated to research as well as commercial production) can be found in Australia, Chile, China, France, Ireland, Italy, Japan, Mexico and Norway. Cobia (*Rachycentron canadum*) are being produced by Aquasense, LLC in South Eleuthera, Bahamas, and off Calebra Island, Puerto Rico. The only two permitted commercial open ocean farms in U.S. state waters can be found in Hawaii. Cates International produces Pacific threadfin (moi; *Polydactylus sexfilis*) while Kona Blue Water Farms, LLC is producing amberjack, Hawaiian yellowtail (kampachi; *Seriola rivoliana*). Both companies target local markets.

PRINCIPAL IMPEDIMENTS

A variety of issues have been raised with respect aquaculture in the marine environment. Perhaps the most widely cited papers critical of the activity are those of Goldburg and Triplett (1997), Naylor et al. (1998, 2000), and Goldburg et al. (2001). The most widely targeted species for criticism have been penaeid shrimp grown in brackish water ponds and salmon produced in net pens. The criticisms range from issues associated with water quality, impacts on the benthos, use of fishmeal in aquatic animal feeds, use of exotic species and maintenance of genetic integrity to those associated with noise, odors, and interference with navigation. Strong condemnation of a plan to establish a fish and shellfish farm in association with a decommissioned drilling platform

off California was lodged by Belton et al. (2004) who viewed such activities as "a disaster waiting to happen." There have been numerous articles and stories in the media about marine aquaculture, many of which have been critical of the activity.

The aquaculture community has responded to the criticisms by addressing the issues raised and developing sustainable practices in conjunction with mariculture facilities, particularly in North America and Europe. Publications dealing with responsible and sustainable marine aquaculture include Bardach (1997), Costa-Pierce (2002) Stickney and McVey (2002), Bridger and Costa-Pierce (2003), and Jana and Webster (2003).

The focus of attention to date has been largely on mariculture in protected coastal waters. As demonstrated in a study by Parametrix (1990), proper siting of net pen facilities associated with salmon culture in the state of Washington was critical to addressing environmental issues. Biosecurity is important to prevent escapement, thereby addressing the issues of exotic species use and maintenance of genetic integrity. One commonly heard notion is that by moving offshore, producers would avoid many of the criticisms that have been raised with respect to facilities established in coastal waters (see for example, Belton et al. 2004). However, as the need to develop regulations for mariculture in the EEZ became recognized, many of the same criticisms raised by critics of inshore mariculture operations were extended to the offshore as well.

With the Food and Agriculture Organization of the United Nations reporting that world capture fisheries peaked a decade or so ago (see www.fao.org) while demand for fish and shellfish increases throughout the world, aquaculture is seen as the primary source of additional supplies. Worldwide, aquaculture continues to grow, though FAO data consistently show that freshwater finfish production dwarfs that from the marine environment at present.

Table 1. Open Ocean Aquaculture Symposia.

Titles	Locations (Dates)	References
Open Ocean Aquaculture	Portland, Maine, USA (1996)	Polk (1996)
Open Ocean Aquaculture '97	Maui, Hawaii, USA (1997)	Helsley (1998)
Third International Conference on Open Ocean Aquaculture	Corpus Christi, Texas, USA (1998)	Stickney (1999)
Open Ocean Aquaculture IV	St. Andrews, New Brunswick, Canada (2001)	Bridger and Costa-Pierce (2003)
Farming the Deep Blue	Limerick, Ireland (2004)	www.eventznet.ie/ev/ac/bim/deepblue

Proponents of offshore aquaculture see the open ocean as a highly desirable place to establish operations, while opponents see major threats to the environment.

A properly designed and regulated permitting system should ensure that open ocean aquaculture operates without inflicting environmental damage. Major challenges that continue to face the industry involve designing and deploying cages that can withstand storms, dealing with the logistics of working many kilometers from land, and finding species that bring sufficiently high prices to overcome the large difference in costs associated with rearing fish in protected coastal waters as opposed to exposed offshore areas.

Much of the debate surrounding open ocean aquaculture has been focused on exercising strict control over an industry that has yet to be developed to any extent. The committee conducted a very informal e-mail survey of companies known to committee members (approximately 30 were contacted) to determine if there was interest within the commercial aquaculture community in moving into the open ocean. Only seven responses were obtained, so the survey cannot be considered to have scientific credibility, nor was it designed with scientific rigor in mind. The survey was revealing to the extent that lack of a regulatory environment in the U.S. EEZ was seen as an impediment by respondents. No facility has as yet been established in the U.S. EEZ and there appears to be little interest in establishing such a facility in the absence of a regulatory framework and permitting process.

Two responders indicated that expansion into open ocean aquaculture was a current priority for their companies. One of those two reported an interest in installing fish cages in federal waters, while the other reported an interest in working in both state and federal waters. Among the five companies that indicated they were not interested in moving offshore, two had a primary focus on freshwater species, one said aquaculture was ancillary to their activities, and two referred to issues associated with the uncertainty of the regulatory and leasing situation.

In response to a question about whether additional federal research funding is needed to develop demonstration sites, responses ranged from "no" to "possibly." Additional comments on the regulatory situation were made and the

lack of sources of sufficient fingerlings for stocking cages (need for hatcheries) was cited as a major impediment. In response to the final question in the survey that asked respondents what they would like to see in the way of a federal policy on open ocean aquaculture, the following points were mentioned:

- The United States needs to develop regulations and policies that make investing in U.S. open ocean aquaculture more attractive than investing in other countries.
- Leases longer than 10 years should be available, as should long-term loan opportunities.
- There should be "one-stop shopping" for all federal and state permits.
- Regulations should be realistic and encourage investment in open ocean aquaculture.
- Incentives would not be needed if the proper regulatory environment were in place.
- Permitting and regulatory constraints need to be reduced as incentives for investment in capital-intensive open ocean aquaculture systems.
- Clear guidance on how oil and gas platforms can be converted to aquaculture sites needs to be developed.
- Permits should be closely monitored by NOAA Fisheries so poorly managed operations can be improved or eliminated.
- Federal policy should be comprised of clear rules, rapid decision making, and include a predictable process that involves a fixed time frame.

Clearly, there is frustration with the lack of a regulatory framework and a clear permitting process in federal waters. In those areas the states are much further along. Recognition of that problem is not only being voiced by those interested in open ocean aquaculture, but also by government, nongovernmental organizations, the research community, and others.

The "which comes first" situation with open ocean aquaculture in the EEZ is not only associated with permitting. The lack of marine hatchery infrastructure to support the production of sufficient numbers of fingerlings to stock into cages to provide a commercial-scale proof of concept is a major issue. In addition, the engineering of cages and mooring systems must be developed to better protect stocks from storm damage and predators, and also to

maintain operational efficiency for feeding fish and cleaning the cages.

The committee recognizes that there are open ocean aquaculture systems in exposed waters in other countries that are showing commercial promise, though the majority of the activity continues to be in moderately to fairly sheltered waters. In addition to having low labor costs and less concern about potential mariculture-related environmental problems in many parts of the world, some countries provide subsidies and/or tax incentives to open ocean aquaculture operations, all of which put the United States at a competitive disadvantage while the demand for seafood by the American public continues to increase.

RECOMMENDATIONS


We cannot know with any certainty whether aquaculture in the U.S. EEZ will become a commercial reality to any significant extent or even which species may bring high enough returns on investment to entice investment in open ocean culture operations. We do know that there is a need to test the concept in the U.S. EEZ. With that in mind, the committee has developed the following recommendations.

1. Put open ocean aquaculture legislation on the fast track through Congress and encourage the Fishery Management Councils to adopt amendments to their management plans that will provide a permitting framework in the absence of broader legislation.
2. Support the development of an Office of Sustainable Aquaculture in NOAA that would provide "one-stop shopping" for moving through the regulatory and permitting process.
3. Encourage the federal and state agencies that will be involved to sign memoranda of understanding (MOUs) with NOAA under which a smooth and efficient process for obtaining permits would be developed. Those agencies would include, but not be limited to U.S. Fish and Wildlife Service, Minerals Management Service, U.S. Army Corps of Engineers, the coastal states (through their Coastal Zone Management Programs), and perhaps others.
4. Develop a regulatory environment that protects native marine communities, native fisheries, and the environment

while not imposing unreasonable monitoring requirements in recognition of the fact that the first commercial facilities will be operating largely as research operations. Increasing the frequency and intensity of monitoring as well as adding parameters to be monitored may be required as research facilities expand into commercial production.

5. Promote the establishment of commercial hatcheries in regions of the country where interest in open ocean aquaculture is strong and support the funding of research on appropriate species of commercial value that might be produced in those hatcheries.
6. Expand NOAA's aquaculture research funding and promote collaboration between university researchers and industry in developing both open ocean aquaculture facilities and the hatcheries and development of species required to stock the facilities.

These recommendations would support the first steps toward development of an open ocean aquaculture industry that would be both economically and environmentally sustainable. As the industry

develops and data are gathered, regulators, producers, and researchers will be better able to develop guidelines for species selection, stocking densities, facility footprints and distances between sites, environmental monitoring and reporting requirements, and deal with other issues that may arise using the adaptive management approach. 

REFERENCES CITED

Bardach, J. E. Editor. Sustainable aquaculture. John Wiley and Sons, New York.

Belton, B., M. Skladany, and J. Volpe. 2004. Out of sight and out of mind: open ocean aquaculture is a disaster waiting to happen. Institute for Agriculture and Trade Policy, Minneapolis, Minnesota. Available at: www.iatp.org/iatp/library/admin/uploadedfiles/Out_of_Sight_and_Out_of_Mind_Open_Ocean_Aquaculture.pdf.

Borgatti, R., and E. H. Buck. 2006. Open ocean aquaculture. Congressional Research Service, Washington, DC. Available at: <http://ncseonline.org/nle/crsreports/06apr/RL32694.pdf>.

Bridger, C. J. Editor. 2004. Efforts to develop a responsible offshore aquaculture industry in the Gulf of Mexico: a compendium of offshore aquaculture consortium research. Mississippi-Alabama Sea Grant Consortium, Ocean Springs, Mississippi.

Bridger, C. J., and B. A. Costa-Pierce. Editors. 2003. Open ocean aquaculture: from research to commercial reality. World Aquaculture Society, Baton Rouge, Louisiana.

Cicin-Sain, B., S. M. Bunsick, J. Corbin, M. R. DeVoe, T. Eichenberg, J. Ewart, J. Firestone, K. Fletcher, H. Halvorson, T. MacDonald, R. Rayburn, R. Rheault and B. Thorne-Miller. 2005. Recommendations for an operational framework for offshore aquaculture in U.S. federal waters. Gerard J. Mangone Center for Marine Policy, University of Delaware, Newark. Available at: <http://darc.cms.udel.edu/sgeez/sgeez2final.pdf>.

Costa-Pierce, B. Editor. 2002. Ecological aquaculture. Blackwell Science, Malden, Massachusetts.

Goldburg, R., and T. Triplett. 1997. Murky waters: environmental effects of aquaculture in the United States.

Environmental Defense Fund, Washington, DC.

Goldburg, R., M. Elliot, and R. Naylor. 2001. Marine aquaculture in the United States. Pew Oceans Commission, Arlington, Virginia.

Helsley, C. 1998. Open Ocean Aquaculture '97. Charting the future of ocean farming. Proceedings of an international conference. University of Hawaii Sea Grant College Program Publication #CP-98-08, Honolulu.

Jana, B., and C. Webster. Editors. 2003. Sustainable aquaculture: global perspectives. Food Products Press, Binghamton, New York.

Naylor, R., R. Goldburg, H. Mooney, M. Beveridge, J. Clay, C. Folke, N. Kautsky, J. Lubchenco, J. Primavera and M. Williams. 1998. Nature's subsidies on world fish supplies. *Science* 282:883-884.

Naylor, R., R. Goldburg, J. Primavera, N. Kautsky, M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effects of aquaculture on world food supplies. *Nature* 405:1017-1024.

Parametrix, Inc. 1990. Fish culture in floating net-pens. Final programmatic environmental impact statement prepared for the Washington Department of Fisheries, Olympia.

Polk, M. 1996. Open ocean aquaculture. Proceedings on an international conference, May 8-10, 1996. New Hampshire-Maine Sea Grant College Program Publication #UNHMP-CP-SG-96-9.

Stickney, R. 1997. Offshore mariculture. Pages 53-86 in J. E. Bardach, ed. Sustainable aquaculture. John Wiley and Sons, New York.

Stickney, R., and J. McVey. 2002. Responsible marine aquaculture. CABI Publishing, Oxon, United Kingdom.

_____. 1999. Joining forces with industry. Proceedings of the Third International Conference on Open Ocean Aquaculture, May 10-15, 1998. Texas A&M University Sea Grant College Program Publication TAMU-SG-99-103, College Station.


U.S. Commission on Ocean Policy. 2004. An ocean blueprint for the 21st century. U.S. Commission on Ocean Policy. Washington, D.C. Available at www.oceancommission.gov.

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